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BY

CARLOTTA JOAQUINA MAURY

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SANTO DOMINGO TYPE SECTIONS AND FOSSILS

PART II : STRATIGRAPHY

By C. J. MAURY

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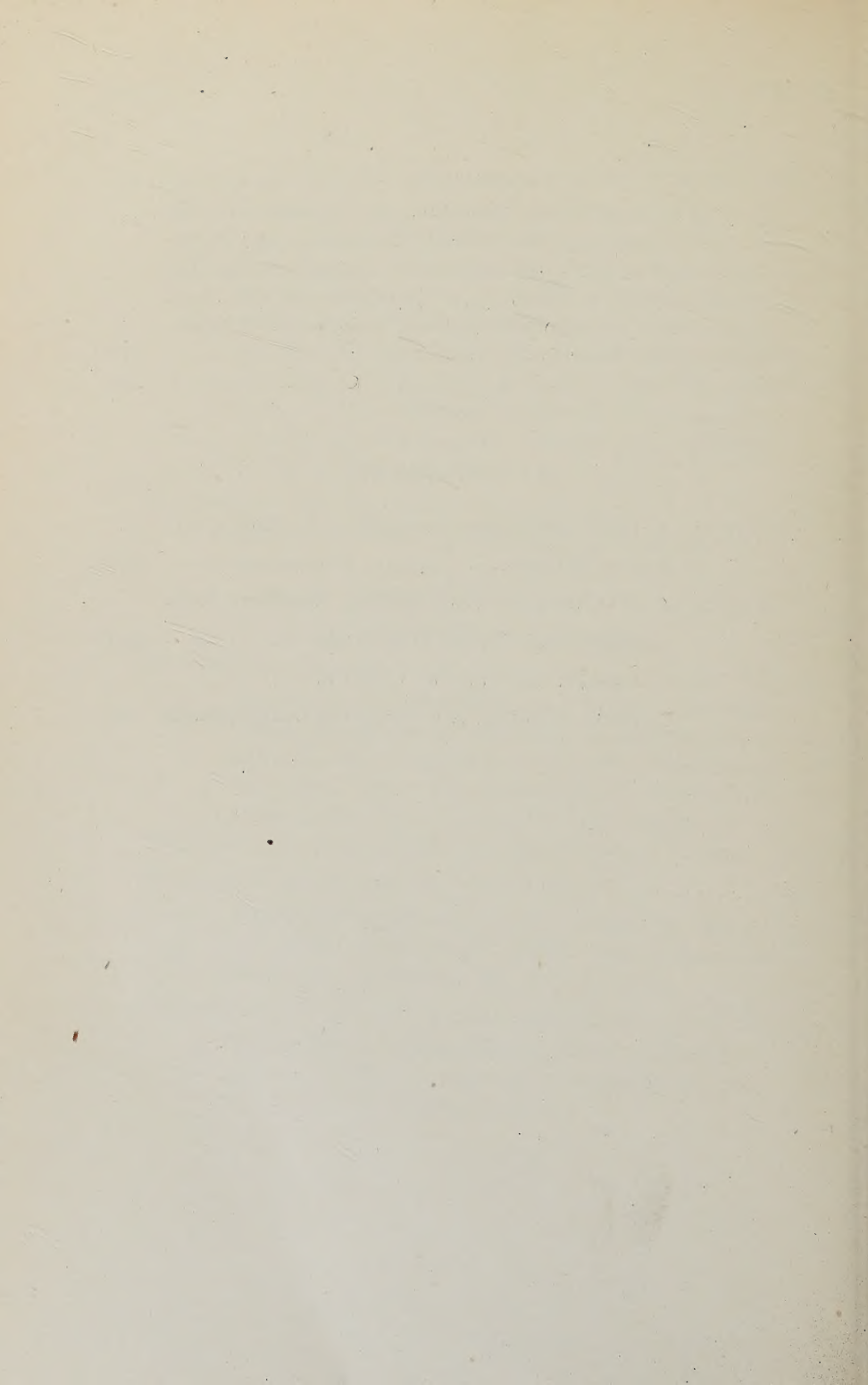
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SANTO DOMINGO TYPE SECTIONS AND FOSSILS

PART II

STRATIGRAPHY

PRELIMINARY NOTE

Since the publication and distribution of Bulletin of American Paleontology, No. 29, Sections 1 and 2, comprising the systematic discussion of our Santo Domingo fossils, quite a number of Gabb's 1873 shells in the Philadelphia Academy's collection have been described, without figures, as new species by Drs. Pilsbry and Johnson.* No doubt a number of these are not represented in our collections and should be added to the Santo Domingo fauna. Some species, however, described as new by Drs. Pilsbry and Johnson will prove identical with mine and will pass into synonymy, since mine have priority. For, Section 1 (pages 1-120) of Bulletin 29 was published and distributed March 31, 1917 and Section 2 (pages 121-240), April 29, 1917, while Drs. Pilsbry and Johnson's *Advance Descriptions* were not issued until May 4, 1917, as stated on the cover of their separates.

CHARACTERISTICS OF THE FOSSIL FAUNAS

Our faunas, systematically discussed in Bulletin 29, forming Part 1 of this memoir, show three striking features which are to some degree deceptive:—(1) Many resemble the recent. (2) The nearest living allies of certain species are deep sea forms. (3) The

*New Mollusca of the Santo Domingan Oligocene. Proc. Acad. Nat. Sci. Phila., designed for the April number which was not issued in April. Advance separates issued May 4, 1917.

modern representatives of others are Pacific, living on the West Coast of the Americas, or more rarely are found in the Indian Ocean. Sowerby* was struck by this on examining Heneken's collection in 1849.

Resemblance to the recent.—At first glance the fossils seem so like the recent that one would not attribute to them their real antiquity. But actual comparisons show that in the great majority of cases the fossils are not absolutely the same but are ancestral, being the stock from which the recent has evolved. Yet in a few instances they have lived on without apparent change agreeing perfectly with recent specimens collected by our party on the Monte Cristi beach where several hundred recent species were gathered.

More exact study of the Bowden and Santo Domingo faunas has much reduced the proportion of the recent. Gabb† gave for his Santo Domingo collection 217 extinct species and 97 recent forms, while of the 451 species discussed by the writer in Part I of this memoir only 34 are regarded as identical with the recent, and some of these are considered doubtful.

Deep Sea Affinities.—Our faunas as a whole are made up of molluscan genera inhabiting warm seas at moderate or shallow depths, many being dwellers on coral reefs. And Dr. Cushman who has most kindly studied our collections of *Foraminifera* informs me that no characteristic deep sea genera are present although certain ones may also be found at some depth. The general character is against deep water conditions especially the abundance of *Orbitolites* and *Amphistegina* which are typical of shallow water. The same is indicated by our hermit crabs from Bluff 3.

Nevertheless a few forms have their nearest allies in deep water. For example *Noëtia* (*Sheldonella*) *maoica* recalls certain deep water *Bathycarcas* and *Cucullarias*. The probable descendant of *Crepidacella cepula* is *C. Gabbi* found in nearly freezing

*Quart. Jour. Geol. Soc. London, vol. 6, 1850.

†Trans. Amer. Phil. Soc. vol. 15, p. 101, 1873.

water at 785 fathoms. The genus *Borsonia* is now restricted to the abyssal zone of the Antilles and Brazil. *Protocardia islahispaniolæ* is represented by the deep sea *P. perāmabilis*. The nearest ally of *Sconsia lævigata* is *S. barbudensis*, dredged off Barbuda.

These cases might tempt one to imagine deep sea conditions for our faunas but for the weight of evidence of the shallow water species. We must conclude that the ancestors of these deep sea forms inhabited shallow water and that their descendants have since resorted to deep sea life from stress of circumstances.

The Pacific and Oriental Elements in the Faunas.—The majority of our molluscan species are the ancestors of species now living in the Antilles. Many have continued on almost without change since the deposition of the blue clays. The Atlantic element is very strong. Yet certain genera and species are now represented only in the recent faunas of the Pacific coast of the Americas, the Oriental seas and the Indian Ocean. This Pacific and exotic element speaks in favor of the Oligocene age of our fossil faunas, since the western migrants presumably crossed into the Pacific before the closing of the Isthmus at the end of the Oligocene, and clearly the Antillean stock existed prior to that elevation. There are, however, two weak points in this line of reasoning:—(1) Our species *may* have lived on undisturbed after the Oligocene and so represent a later period of time; (2) Dr. Vaughan* has suggested a later interocean water way in the Upper Miocene or Pliocene, possibly located in the region of the Isthmus of Tehuantepec.

Of exotic genera we may mention *Surcula*, now restricted to the Indian Ocean, *Meta* found in the Malay archipelago, [*Metula* in the China seas and off the Cape. Illustration of Pacific species living on the West Coast of the Americas and showing a close kinship to our Dominican fossil shells are *Conus pyriformis* representing *C. recognitus*; *Cancellaria urceolata* allied to *C. Rowelli*;

*See Reef Coral Fauna of Carrizo Creek, U. S. G. S. Prof. Paper 98, p. 369, 1917.

Phos veraguensis representing *Phos Moorei*; *Malea ringens* resembling *M. camura*; *Neverita glauca*, close to *N. nereidis*; *Scapharca grandis* almost identical with *S. patricia*; *Tellina* (*Scissula*) *delicatula* very like *T. cercadica*; *Sanguinolaria* (*Psammotella*) *operculata* resembling *S. Smithwoodwardi*; *Miltha childreni* living in the Gulf of California, related to *M. Smithwoodwardi*. The Oriental *Bursa bufonia* is allied to *B. bufoniopsis* and *Cypræa* (*Pustularia*) *nucleus*, also Oriental, represents *C. Gabbiana* in the fossil fauna. A singular example of the Pacific element in our faunas is furnished by the two *Ostreas*, *O. hailensis* and *O. megodon* both also at Bowden, and forms identical or very closely related are found on Cerros Island off the Californian coast. Finally the marked resemblance of *Costellaria cadaverosa* from the Philippines to *C. Bullennewtoni* may be noted.

The Evidence of the Arcas.—An argument favoring the very considerable antiquity of the horizons studied is the undifferentiated character of the *Arcas*. Not, however, earlier than Oligocene because of the presence of so many *Scapharcas* of the short, erect, highly specialized type. Many of the species show characters of more than one section and appear to have developed before the latter became defined and crystallized. They show mixed sectional features. For example, *S. hispaniolana* is a *Cuncarca* with the cardinal area of *Scapharca* still remaining. The related species *S. cor-cupidonis* and *S. riocanensis* also have the cardinal area of *Scapharca* with other characters of *Cuncarca*, while *C. Willardausteni* is not so highly specialized as modern members of the group. *S. Arthurpennelli* is an *Argina* externally, but vacillates between the cardinal area of *Argina* and *Scapharca* and the teeth are intermediate. In brief our fossil *Arcas* apparently lived before the modern sections were definitely evolved.

Species in common with Bowden.—Of the four hundred and fifty-one species discussed in the systematic part of this report one hundred and twelve are known to occur at Bowden. That is, slightly less than a quarter of the Santo Domingo species were

also living on the neighboring Jamaican coast. Dr. Dall in 1903* noted that nearly 20 per cent of the Bowden species were common to the Santo Domingo fauna. Our collections show that of Dall's *definitely identified* species at Bowden 40 per cent are common to the fauna of Santo Domingo. The reciprocal percentage is 9. Further study will doubtless add a still greater proportion in common, for the faunas were very closely allied.

Species in common with Trinidad.—Identified by Dr. Guppy.

List of Species

M=Manzanilla beds, C=Caroni Series, F=San Fernando.

Ateocina ovum-lacerti Gpy., C.	Cymia Henekeni Maury.
Conus gracilissimus Gpy., M.	Turritella planigyrate Gpy., C.
Conus planiliratus Sby., C.	Solarium quadriseriatum Sby., C.
Conus marginatus Sby., M.	Natica canrena Linné.
Drillia venusta Sby.	Amauropsis Guppyi Gabb, F.
Oliva cylindrica Sby., C.	Petalocochus domingensis Sby., C.
Mitra Henekeni Sby., C.	Barbatia reticulata Gm.
Latirus infundibulum Gm., C.	Scapharca patricia Sby., C.
Xancus validus Sby., C.	Crassinella Guppyi Dall.
Murex domingensis Sby., C.	Metis trinitaria Dall, C.
	Corbula (Aloidis) vieta Gpy., M.

A striking form like *Amauropsis Guppyi* allies the San Fernando beds with our Zone G and Bluff 2, while *Petalocochus domingensis* shows a bond between the Caroni Series and our Bluff 1 and Zone B faunas. *Corbula vieta* allies the Manzanilla beds with our Bluff 2 and Zone I.

Species in common with Cumana, Venezuela.—The Cumana beds have been studied by Guppy. They furnish the following species in common with our Dominican beds :

List of Species

Terebra inaequalis Sby.	Crepidacella cepula Sby.
Conus gracilissimus Gpy.	Cerithium uniseriale Sby.
Turris albida Perry.	Natica sulcata Born.
Clava plebeia Sby.	Scapharca tolepiea Dall.
Oliva cylindrica Sby.	Scapharca cumanensis Dall.

*Trans. Wagner Inst. Sci., vol. 3. pt. 6, p. 1582, 1903.

Melongena consors Sby.
 Phos elegans Gpy.
 Murex domingensis Sby.

Glycimeris acuticostata Sby.
 Pecten soror Gabb
 Cardium haitense Sby.

Species in common with Gatun.—The rich collections from the Isthmus in the National Museum have only begun to be studied by Dr. Cooke. When the work is finished a more complete comparison can be made with the Dominican faunas than is now possible. In the present state of our knowledge of the Isthmian faunas it appears to me that comparatively few species are actually identical but many are analogous. These analogies have in many cases been mentioned in the systematic discussion of our faunas in Bulletin 29 and doubtless Dr. Cooke's work will bring many more to light. Among the species common to the Isthmus and our faunas may be mentioned:

List of Species

Terebra gatunensis Toul.	Phos metuloides Dall.
Terebra Wolfgangi Toul.	Murex messorius Sby.
Conus haytensis Sby.	Sconsia lævigata Sby.
Conus molis B. and P.	Malea camura ? Gpy.
Conus symmetricus domingensis Sby.	Petalochonchus domingensis Sby.
Conus consobrinus Sby.	Natica canrena (Linné) Mörch.
Conus tortuosostriatus Toul.	Polinices subclausa Sby..
Conus gaza J. and P.	Sinum gatunense Toul.
Conus Dalli Toul.	Glycimeris acuticostata Sby.
Turris albida Perry.	Pecten scissuratus Dall.
Drillia consors Sby.	Cardium dominicanum Dall.
Oliva cylindrica Sby.	Cardium serratum Linné.
Marginella conformis Sby.	Pitaria circinata Born.
Mitra longa Gabb.	Corbula viminea Gpy.

Of this list 9 occur in our Bluff 1, 8 in Bluff 3, 6 in Bluff 2, Cercado. This strongly suggests that more than one faunal zone is represented at Gatun because of the faunal break between our Bluff 1 fauna and that of Bluffs 2 and 3. It will be interesting to see whether Dr. Cook does not find more than one zone at Gatun.

Species in common with Florida.—Comparatively few of our Dominican fossils occur in the Oligocene of Florida. Among these the following may be cited:

List of Species

C=Chipola, T=Tampa silex beds, W=White Beach limestone.

<i>Terebra bipartita</i> Sby., C.	<i>Ostrea haitensis</i> Sby., C. O. G.
<i>Lyria pulchella</i> Sby., T.	<i>Liphophaga antillarum</i> d'Orbigny, T.
<i>Morum domingense</i> Sby., T.	<i>Liphophaga nigra</i> d'Orbigny.
<i>Orthaulax inornatus</i> Gb., T. W.	<i>Phacoides domingensis</i> Dall.
<i>Arca umbonata</i> Lamarck.	<i>Pitaria planivieta</i> ? Gpy., W.
<i>Barbatia reticulata</i> Gm., T. and C.	<i>Antigona tarquinia</i> Dall, T.
	<i>Siliqua subæqualis</i> ? Gabb, C.

Orthaulax links the Tampa beds to the *Orthaulax* zone.

GEOLOGY OF THE RIVER MAO

Our explorations were made near Cercado de Mao of which a general view is shown in the frontispiece, Bulletin 29, and the location of the hamlet is indicated as number 13 on the Sketch Map facing page 10 of that bulletin. Views of Rio Mao are shown Plates 1B and 2B of this bulletin; photographs were taken by Mr. K. P. Schmidt. Cercado is one of the oldest of the Santo Domingo type localities where Colonel Heneken made his first collection in 1849.* Our section is a generalized one obtained from successive high bluffs met with on ascending the river.

Section at Cercado de Mao

	Feet
Bluff No. 1. A mile above Cercado. Composed of blue clays locally hard and brittle. No limestone. Fossils abundant and well preserved. Height of bluff approximately.....	200
Bluff No. 2. Four miles above Cercado. Blue clays with layers formed of masses of Foraminifera which appear like fine gravel. Fossil mollusca occur in lenses and are quite abundant. Height about.....	200
Bluff No. 3. Five miles above Cercado. Bluff composed of blue clays and sand with layers of marl. Tellinas abundant. Furoids and Bryozoa in the sandy layers. Fauna exceedingly rich. Height approximately.....	200

*See Quart. Jour. Geol. Soc. London, vol. 6, 1850; vol. 9, 1853; vol. 22, 1866.

Fauna of Bluff 1.—The following species were collected at Bluff 1, Cercado:

List of Species

<i>Terebra haitensis</i> Dall.	<i>Murex domingensis</i> near <i>yaquensis</i> .
<i>Conus haytensis</i> Sby.	<i>Murex cornurectus</i> Gpy.
<i>Conus Sewalli</i> , n. sp.	<i>Distortrix simillima</i> Sby.
<i>Conus stenostomus</i> Sby.	<i>Cassisi sulcifera</i> Sby.
<i>Conus granozonatoides</i> , n. sp.	<i>Sconsia lævigata</i> Sby.
<i>Conus gaza</i> J. and P.	<i>Morum domingense</i> Sby.
<i>Conus Karlschmidti</i> , n. sp.	<i>Cypræa Henekeni</i> Sby.
<i>Surcula riomaonis</i> , n. sp.	<i>Cypræa Noueli</i> , n. sp.
<i>Turris albida</i> Perry.	<i>Cypræa spurca</i> Linné.
<i>Turris albida antillarum</i> Crosse.	<i>Cypræa spurcoides</i> Gabb.
<i>Drillia cercadonis</i> , n. sp.	<i>Cypræa patrespatriæ</i> , n. sp.
<i>Drillia venusta</i> Sby.	<i>Strombus haitensis</i> Sby.
<i>Drillia Henekeni</i> Sby.	<i>Strombus bifrons</i> Sby.
<i>Drillia isalindæ</i> , n. sp., var.	<i>Strombus proximus</i> Sby.
<i>Cythara cercadica</i> , n. sp.	<i>Strombus maoënsis</i> , n. sp.
<i>Cancellaria Barretti</i> Gpy.	<i>Crepitacella cepula</i> Gpy.
<i>Cancellaria epistomifera</i> Gpy.	<i>Solarium quadriseriatum</i> Sby.
<i>Cancellaria Guppyi</i> Gabb.	<i>Xenophora delecta</i> Gpy.
<i>Oliva cylindrica</i> Sby.	<i>Natica canrena</i> Linné.
<i>Marginella coniformis</i> Sby.	<i>Natica Youngi</i> n. sp.
<i>Lyria pulchella</i> Sby.	<i>Amiaupopsis Guppyi</i> Gabb.
<i>Mitra Henekeni</i> Sby.	<i>Scapharca golfoyaquensis</i> , n. sp.
<i>Mitra Berlineri</i> , n. sp.	<i>Scapharca cercadica</i> , n. sp.
<i>Fusus Henekeni</i> Sby.	<i>Glycimeris acuticostata</i> Sby.
<i>Fasciolaria semistriata</i> Sby.	<i>Pecten soror</i> ? Gabb.
<i>Fasciolaria carminamaris</i> , n. sp.	<i>Pecten excentricus</i> Gabb.
<i>Xancus præovoideus</i> , n. sp.	<i>Spondylus bostrychites</i> Gpy.
<i>Metula cancellata</i> Gabb.	<i>Echinochama antiquata</i> Dall.
<i>Phos Moorei</i> Guppy, (var.)	<i>E. antiquata yaquensis</i> , n. var.
<i>Metulella venusta</i> Sby.	<i>Cardium serratum</i> Linné.
<i>Typhis cercadicus</i> , n. sp.	<i>Antigona Blandiana</i> Gpy.
<i>Murex domingensis</i> Sby.	<i>Chione Hendersoni</i> Dall.

Affinities of the Bluff 1 Fauna.—Of this list of Bluff 1 species 45 per cent occur at Bowden, 28 in Zone F, 25 in Zone B, 23 in Zone A, 17 in Bluff 3, 12 in Bluff 2 and 12 in Zone G. But since the number of species in the beds is unlike, the mutual or reciprocal percentage gives a truer relation. For example 28 per cent of the Bluff 1 species occur in



A. Rio Yaguaja' near Sabaneta



B. Bluff 3, Rio Mao at Cercado

Zone F and 70 per cent of the Zone F species occur in Bluff 1 and the product of these two percentages gives 19.6. This we call the reciprocal percentage which expresses the *purely mathematical* proportion. The reciprocal percentages of the Bluff 1 fauna are as follows:— 19.6 to F, 14 to A, 10 to B, 4.5 to Bowden, 3 to Bluff 3, 2 to G, 1.5 to Bluff 2. This reveals a remarkably strong bond to F, also a rather strong alliance with A and B; but a very marked faunal break between Bluff 1 and Bluffs 2 and 3. G is also set apart from Bluff 1.

Fauna of Bluff 2.—The following species were collected at Bluff 2, Cercado :

List of Species

Acteocina triticum-tritonis, n. sp.	Dentalium dissimile Gpy.
Volvula cylindrica Gabb.	Dentalium dissimile
Terebra spirifera Dall.	var. ponderosum Gabb.
Conus furvovides Gabb.	Cadulus phenax P. and S.
Turris albida Perry.	Cadulus elegantissimus P. and S.
Drillia maonisripurum, n. sp.	Leda peltella Dall.
Mangilia Lalonis, n. sp.	Arca yaquensis n. sp.
Cythara gibba Gpy.	Scapharca Henekeni, n. sp.
Cythara elongata Gabb.	Scapharca cibaoica n. sp.
Cancellaria Barretti Gpy.	Scapharca cor-cupidonis, n. sp.
Cancellaria islacolonis, n. sp.	Scapharca Arthurpennelli, n. sp.
Oliva brevispira Gabb.	Glycimeris acuticostata Sby.
Olivella muticoides Gabb.	Pteria inornata Gabb.
Latirus fusiformis Gabb.	Pecten excentricus Gabb.
Phos Gabbi Dall.	Pecten cercadica, n. sp.
Alectrion cercadensis, n. sp.	Anomia simplex d'Orb.
Murex cornurectus Gpy.	Crenella divaricata d'Orb.
Cassis sulcifera Sby.	Pandora inconspicua Gabb.
Malea camura Gpy.	Crassinella Guppyi Dall.
Cerithium uniseriale Sby.	Venericardia scabricostata Gpy.
Turritella planigrata Gpy.	Phacoides domingensis Dall.
Rissoina crassilabris Gabb.	Miltha Smithwoodwardi, n. sp.
Rissoina Sagraiana d'Orb.	Cardium dominicanum Dall.
Crucibulum cf. pileolum H. C. Lea.	Cardium haitense Sby.
Natica Youngi, n. sp.	Cardium haitense
Natica sulcata Born.	var. cercadicum, n. var.
Polinices subclausa Sby.	Cardium venustum Gabb.

Amauropsis Guppyi Gabb.	Pitaria planivieta Gpy.
Neritina viridemarais, n. sp.	Chione Woodwardi Gpy.
Phasianella punctata Gabb.	Chione cf. Walli Gpy.
Turbo dominicensis Laloi, n. var.	Semele Claytoni, n. sp.
Corbula vieta Gpy.	

Affinities of the Bluff 2 Fauna.—Of this list 64 per cent occur in Bluff 3, 40 at Bowden and 13 in Bluff 1. The reciprocal percentages are 15 to Bluff 3, 3 to Bowden, 1 to Bluff 1. That is, Bluffs 2 and 3 are linked together closely and have a bond with Bowden, but are sharply set off from Bluff 1.

Literally millions of *Amphistegina* are present in Bluff 2.

Fauna of Bluff 3.—The following species were collected at Bluff 3, Cercado :

List of Species

Cavolina near gibbosa R.	Niso grandis Gabb.
Acteon riomaensis, n. sp.	Pyramidella canaliculata Gabb.
Acteocina canaliculata Say.	Pyramidella semicanaliculata, n. sp.
Acteocina recta d'Orb.	Pyramidella diademata, n. sp.
Acteocina triticum-tritonis, n. sp.	Pyramidella Olssoni, n. sp.
Volvula cylindrica Gabb.	Pyramidella cercadensis, n. sp.
Retusa yaquensis, n. sp.	Pyramidella Arionis, n. sp.
Atys doliolum, n. sp.	Turbonilla Ogilvieæ, n. sp.
Bullaria paupercula Sby.	Turbonilla yaquensis, n. sp.
Ringicula dominicana, n. sp.	Turbonilla cercadensis, n. sp.
Terebra spirifera Dall.	Turbonilla dominicensis Gabb.
Terebra cirrus Dall.	Turbonilla Karlschmidt, n. sp.
Terebra oligomitra Dall.	Turbonilla Olssoni, n. sp.
T. gausapata lævifasciola, n. var	Turbonilla turritissima Gpy.
Terebra Cambiarsoi, n. sp.	Turbonilla riomaensis, n. sp.
Terebra gatunensis Toul.	Turbonilla turritelloides Gabb.
Conus molis B. and P.	Turbonilla Nanniebellæ, n. sp.
Conus cercadensis, n. sp.	Odostomia Sancti-Dominici, n. sp.
Conus recognitus Gpy.	Odostomia yaquica, n. sp.
Turris albida Perry.	Neritina viridemarais, n. sp.
Drillia Henekeni Sby.	Phasianella punctata Gabb.
Drillia maonisriparum, n. sp.	Astraliu sublongispinum, n. sp.
Mangilia maica, n. sp.	Astraliu Karlschmidt, n. sp.
Mangilia Lalonis, n. sp.	Circulus striata Gabb.

- Cythara elongata* Gabb.
Cancellaria Barretti Gpy.
Cancellaria epistomifera Gpy.
Cancellaria islacolonis, n. sp.
Oliva brevispira Gabb.
Olivella indivisa Gpy.
Marginella maoënsis, n. sp.
Persicula cercadensis, n. sp.
Lyria pulchella Sby.
Fusus Henekeni Sby.
Fusus Henekeni haitensis Sby.
Xancus præovoideus, n. sp.
Melongena consors Sby.
Phos Gabbi Dall.
Phos costatus Gabb.
Phos fasciolatus Dall.
Nassarina Olssoni, n. sp.
Alectrion cercadensis, n. sp.
Tritia golfoyaquensis, n. sp.
Meta islahispaniolæ, n. sp.
Meta perplexabilis, n. sp.
Strombina pseudohaitensis, n. sp.
Anachis exilis Gabb.
Astyris DeBooyi, n. sp.
Murex messorius Sby.
Murex cornurectus Gpy.
Simpulum antillarum,
 var. *cercadicum*, n. var.
Bursa Amphitrites, n. sp.
Cassis sulcifera Sby.
Phalium moniliferum Gpy.
Phalium moniliferum reclusum Gpy.
Malea camura Gpy.
Ovula Wise-Woodæ, n. sp.
Trivia islahispaniolæ, n. sp.
T. suffusa Sancti-Dominici, n. var.
Erato Mangeriæ domingensis, n. var.
Strombus bifrons Sby.
Strombus proximus Sby.
Bittium asperoides Gabb.
Bittium canaliculatum Gabb.
Solarium quadriseriatum Sby.
Solarium Stonemanæ, n. sp.
Teinostoma sandomingense, n. sp.
Discopsis Derbyi, n. sp.
Fissurida alternata Say.
Dentalium dissimile Gpy.
Dentalium haytense Gabb.
Cadulus phenax P. and S.
Cadulus elegantissimus P. and S.
Nucula tenuisculpta Gabb.
Leda peltella Dall.
Arca yaquensis, n. sp.
Barbatia reticulata Gm.
Noëtia maoica, n. sp.
Scapharca Henekeni, n. sp.
Scapharca cibaoica, n. sp.
Scapharca cor-cupidonis, n. sp.
Scapharca Arthlurpennelli, n. sp.
Pteria inornata Gabb.
Ostrea virginica Gm.
Pecten excentricus Gabb.
Pecten Thompsoni, n. sp.
Modiolus cercadicus, n. sp.
Modiolus maonis, n. sp.
Pandora inconspicua Gabb.
Cuspidaria islahispaniolæ, n. sp.
Lucina chrysostoma Philippi
Phacoides hispaniolana, n. sp.
Phacoides cercadica, n. sp.
Phacoides yaquensis Gabb.
Divaricella prevaricata Gpy.
Diplodonta capuloides Gabb.
Diplodonta puncturella Dall.
Montacuta cercadica, n. sp.
Montacuta maoica, n. sp.
Montacuta hispaniolæ, n. sp.
Cardium dominicanum Dall.
Cardium tintinnabularum, n. sp.
Cardium haitense Sby.
Cardium venustum Gabb.
Pitaria cercadica, n. sp.
Pitaria planivieta Gpy.
Chione Woodwardi Gpy.
Chione cf. *Walli* Gpy.
Tellina islahispaniolæ, n. sp.

Rissoina crassilabris Gabb.	Tellina maoica, n. sp.
Rissoina Sagraiana d'Orb.	Merisca crystallina Chem.
Crucibulum cf. pileolum H. C. Lea.	Merisca Sancti-Dominici, n. sp.
Natica sulcata Born.	Scissula cercadica, n. sp.
Polinices subclausa Sby.	Scissula scitula Dall.
Sinum gatunense Toul.	Strigilla pisiformis Linné.
Epitomium minutissimum Gabb.	Psammacoma yaquensis, n. sp.
Epitomium riparum, n. sp.	Cymatoica hispaniolæ, n. sp.
Epitomium cercadicum, n. sp.	Psammosolen Sancti-Dominici, n. sp.
Triforis Calypsonis, n. sp.	Donax æqualis Gabb.
Aclis acuminatoides, n. sp.	Sanguinolaria Smithwood-
Melanella cercadica, n. sp.	wardi, n. sp.
Melanella maoica, n. sp.	Siliqua subæqualis Gabb
Melanella jacululum, n. sp.	Mactrella cf. alata Spengler.
Melanella Tethyos, n. sp.	Corbula cercadica, n. sp.

Affinities of the Bluff 3 Fauna.—Of this list 24 per cent occur in Bluff 2, 23 at Bowden, 15 in Zone I, 13 in Zone H, 9 in the Bulla river bluff, 9 in Zone G, 6 in Bluff 1 and 4 in Zone F. The reciprocal percentages are 15 to Bluff 2, 7 to Bulla river, 6 to Zone I, 4 to Zone H, 3 to G, 2.9 to Bowden, 1 to Bluff 1, .92 to Zone F.

The strongest bond is with Bluff 2; 1 and F are sharply set off; the tie with G is weak.

Evidence of the Foraminifera.—Dr. Joseph A. Cushman has very kindly identified the Foraminifera we collected. There are in all 33 species, chiefly from the Rio Mao and Cana. Dr. Cushman writes that "in general Zones H and I, Rio Cana and Bluffs 2 and 3, Cercado de Mao seem to represent a single unit as far as the Foraminifera show and I should put the age of these Early Miocene or Upper Oligocene, preferably the former."

Thus Bluffs 2 and 3 are linked together and allied to H and I by the Foraminifera just as they are by the Mollusca.

Dr. Cushman tells me that during the deposition of Bluff 2 conditions were evidently very favorable for *Amphistegina* which is so exceedingly abundant.

Apropos of the Santo Domingo Tertiary Foraminifera it may here be mentioned that Gabb used "*Orbitoides*" as a very im-

portant guide in correlation. For example he mentions finding this genus in the rocks of the Monte Cristi range,* and again on the peninsula of Samana.†

At Santa Barbara he remarks ‡ "that the omnipresent *Orbitoides* fortunately appears in some places and thus saves us from the uncertainty that might hang around the age of so exceptional a group of rocks."

Now our party, in the area explored by us, made a special hunt for Gabb's "*Orbitoides*," but found nothing that looked to us like that genus and on asking Dr. Cushman, he writes positively there are no *Orbitoides* in our collection; that in this country as elsewhere the genus is limited to the Cretaceous and *Lepidocyclus*, known as *Orbitoides* also in most American papers, seems to be limited to Lower Oligocene and Upper Eocene. Neither genus is in our collection.

We hope some day to collect from the Monte Cristi range and the Samana rocks in order to find Gabb's "*Orbitoides*," which was doubtless a genus resembling the true *Orbitoides*, perhaps *Lepidocyclus*. The object would be to determine whether these formations are not an older series than the blue clays. This seems extremely probable.

Crustacea of Bluff 3.—We found quite a number of fragmentary remains of various Crustacea, especially crabs' and Hermit crabs' claws. These were submitted to Miss Rathbun who very kindly identified them for me as follows:—*Crangonidae*, ? *Eryonidae*, *Pagurus*, (= *Eupagurus*), *Calappa flammea* (Herbst), *Cycloes bairdii*, ? *Orithyia*, *Persephona*, *Portunus* near *spinicarpus* Stimpson, *Portunus* sp., *Callinectes* 2 species, *Panopeus*, *Xanthidae* or possibly *Goneplacidae* 3 species, *Mesorhœa* new species.

The *Callianassa*, Miss Rathbun notes, is very like and may be identical with a species collected by Dr. Vaughan in the Oligo-

*Trans. Amer. Phil. Soc., vol. 15, p. 167, 1873.

†Idem., p. 174.

‡Idem., p. 177.

cene of Anguilla. This gives us an additional bond with that island.

The family *Eryonidae* now is in deep water and not common. This accords with the deep sea affinities of a number of our molluscs from various Dominican localities. Miss Rathbun further notes that *Orilhyia* is now limited to the East Indies and is scarce. *Calappa flammca* and *Persephona* are Atlantic forms, while *Cycloes bairdii* and *Portunus spinicarpus* are both Atlantic and Pacific in recent time. The same is true of *Mesorhœa*, a rare genus with but two living species, one on the East, the other on the West side of Tropical America. This genus has never before been found as a fossil. These Pacific and East Indies affinities shown by certain of the Crustacea harmonize with the Pacific and East Indian relationships of a number of the mollusca.

Evidence of the Bryozoa.—Dr. Bassler and Dr. Canu, who have been so kind as to identify the Bryozoa we collected, write me that "the Bryozoa indicate a Bowden age of the rocks. Bluffs 2 and 3, Cercado de Mao, have the best faunas and show the relationship most clearly. Rio Cana, Zone I; Rio Amina, Hato Viejo to Potrero; and Rio Gurabo, Zone G, contain few but the same species."

The Molluscan evidence correlating Bluffs 2 and 3 with I and G is thus strengthened by the Bryozoan fauna.

Relation of the Cercado Bluffs Faunas to the Recent Antillean Fauna.—Of the sixty-four molluscan species we collected in Bluff 1 only three have lived on to the present time, namely, *Cypræa spurca*, *Natica canrena* and *Lævicardium serratum*. Three also occur among the sixty one species of Bluff 2, namely, *Rissoina Sagraiana*, *Natica sulcata* and *Anomia simplex*. Of the 162 species of Bluff 3, ten species have lived on nearly or quite unchanged:—*Acteocina canaliculata*, *A. recta*, *Murex messorius*, *Rissoina Sagraiana*, *Natica sulcata*, *Fissuridea alternata*, *Lucina chrysostoma*, *Diplodonta puncturella*, *Merisca crystallina*, *Strigilla pisiformis*. But if the entire number of recent Antillean species were taken into consideration and the reciprocal percentage calculated it

would be an exceedingly small fraction. There is an overwhelming proportion of extinct species.

Relation of the Cercado Bluffs Faunas to the Bowden Fauna.—

The Bluff 1 fauna has the strongest bond with Bowden, but that of Bluffs 2 and 3 is also related to Bowden, the respective reciprocal percentages being 4.5, 3, 2.9. But the Bluff 1 fauna is very unlike the mutually related Bluffs 2 and 3 faunas.

The Bowden Fauna apparently not a unit.—

It would seem that several faunal zones are represented in the Bowden since it has affinities with our dissimilar faunas. That it is not a unit is suggested also by the description of the Bowden bed. Dall* says:

"The bed of marl which contains the rich fauna of Bowden occurs in a calcareous gravel at the foot of Baker's Mill, Morant Bay, Jamaica, about three feet above the sea. Such coarse material as gravel is found that the shells are not in their original *situ*, which would have been farther off where finer material was laid down, deposited, and that they are an assemblage gathered by currents and deposited in the calcareous gravels.

For the above reasons the Bowden fauna is here tentatively subdivided into upper, middle and lower horizons. This theory must be tested by actual study in the field.

GEOLOGY OF THE RIO GURABO

Our explorations on Rio Gurabo were made in the vicinity of Los Quemados which is also one of Hencken's type localities. The location of this hamlet is shown on the Sketch Map (12) facing page 10 of Bulletin 29. A characteristic view of the river bluffs are shown on Plate 3B of this bulletin. Actual superposition does not exist. The section is made up from successive bluffs met with on ascending the river. The lettering is in descending geological order.

The dip at Los Quemados is 16 feet in a hundred, N. 55° E.

*Trans. Wagner Inst. Sci., vol. 3, pt. 6, p. 1583, 1903.

Section at Los Quemados

	Feet
Concealed with vegetation and unexplored.	
Limestone with poorly preserved corals. Approximate thickness	50
Zone A. Hard, light blue clays forming vertical cliffs slightly concave near the base. The clays weather yellowish-white. Fossils rare or absent in the upper parts of the bluffs, abundant below. Fauna chiefly Gastropods. A few Pelecypods as <i>Venericardia</i> and <i>Echinochama</i> . Approximately.....	300
Zone B. Hard blue clays, blocky, not well stratified, weathering grayish. Fossils abundant. Thickness about.....	50
Zone C. Alternating clays and limestones, with a rather heavy bed of the latter above. Fossils very scarce, <i>Cassis sulcifera</i> . Thickness approximately.....	10
Zone D. Hard, blue calcareous clays. Corals. <i>Cerithium</i> abundant. About.....	15
Zone E. Blue, uniform clays with <i>Cerithium</i> , <i>Phos</i> , <i>Cypræa</i> . Approximately	20
Zone F. Hard, greenish clays with concretions. Corals, <i>Cassis</i> , <i>Xenophora</i> . Approximately.....	20
Zone G. Two miles above Los Quemados. Hard, grayish-green clays with sandy layers and limonitic nodules. Strata in general unfossiliferous but lenses very rich in fossils occur. <i>Amauropsis</i> . Few species in common with the preceding zones. Exposed thickness 10 feet, estimated total thickness at least.....	50
Unexplored.	

Fauna of Zone A.—Zones A and B were examined successively and their faunas kept distinct, but they apparently form a stratigraphic unit and might better be grouped as A and B.

We obtained the following species from Zone A :

List of Species

<i>Terebra Petiti</i> , n. sp.	<i>Latirus infundibulum</i> Gm.
<i>Conus catenatus</i> Sby.	<i>Vasum haitense</i> Sby.
<i>Conus granozonatoides</i> , n. sp.	<i>Distortrix simillima</i> Sby.
<i>Turris albida</i> Perry.	<i>Sconsia lævigata</i> Sby.
<i>Turris albida tellæa</i> Dall.	<i>Strombus haitensis</i> Sby.
<i>Turris albida antillarum</i> C.	<i>Strombus bifrons</i> Sby.
<i>Drillia consors</i> Sby.	<i>Solarium quadriseriatum</i> Sby.
<i>Cancellaria epistomifera</i> Gpy.	<i>Natica Youngi</i> , n. sp.
<i>Lyria pulchella</i> Sby.	<i>Scapharca riogurabonica</i> , n. sp.



A. El Morro de Monte Cristi, Northern End



B. Bluff, Rio Mao at Hato Viejo

Mitra Henekeni Sby.	Venericardia islahispaniolæ, n. sp.
Fusus Henekeni Sby.	Echinochama antiquata yaquensis,
Fusus Henekeni haitensis Sby.	n. var.

Antigona Blandiana Gpy.

Affinities of the Zone A Fauna.—Of this list 62 per cent occur in Bluff 1, 58 in Zone B, 41 in Bowden, 29 in Bluff 3, 12 in H, 12 in I. The reciprocal percentages are 19 to Zone B, 14 to Bluff 1, to Bluff 3, 1 to Bowden, .7 to Zone G, .5 to Zone I, .4 to Zone H. It should be noted also that the few species A has in common with H and I, are those with considerable vertical range.

Flora of Zone B.—The top of Zone B contains wood and leaves of the Myrtle, Laurel and Mimosa families. Professor E. W. Berry was so kind as to identify them generically for me but their state of preservation was not good enough for determining the species. The genera represented are *Eugenia*, *Nectandra* and *Inga*. The various woods Dr. Berry remarks are almost surely new species. The range of the genera is such that no special stratigraphic meaning is implied by their presence.

Fauna of Zone B.—The following molluscs were found :

List of Species

Conus haytensis gurabensis, n. sp.	Simpulum pileare Lamarck.
Conus stenostomus Sby.	Distortix simillima Sby.
Turris albida Perry.	Bursa bufoniopsis, n. sp.
Turris albida antillarum Crosse.	Cassis sulcifera Sby.
Drillia fusiformis Gabb.	Sconsia lævigata Sby.
Drillia venusta Sby.	Crepidacella cepula Gpy.
Drillia squamosa Gabb.	Crepidacella cepula spiralistriata,
Clava plebeia Sby.	n. var.
Marginella Christineladdæ, n. sp.	Cerithium uniseriale Sby.
Lyria pulchella Sby.	Serpulorbis granifera Say.
Mitra Henekeni Sby.	Solarium quadriseriatum Sby.
Fusus Henekeni Sby.	Natica Youngi, n. sp.
Fusus Henekeni haitensis Sby.	Turbo crenulatoides, n. sp.
Latirus infundibulum Gm.	Scapharca Henekeni, n. sp.
Latirus exilis Gabb.	Scapharca golfoyaquensis, n. sp.
Vasum haitense Sby.	Scapharca riogurabonica, n. sp.

Glycimeris acuticostata Sby.	Echinochama antiquata yaquensis,
Pecten eugrammatus Dall.	n. var.
Spondylus bostrychites Gpy.	Cardium Cinderellæ, n. sp.
Venericardia islahipaniolæ, n. sp.	Protocardia islahispaniolæ, n. sp.
Antigona Blandiana Gpy.	

Affinities of the Zone B. Fauna.—Of the above 41 per cent occur in Bluff 1, 33 at Bowden, 10 in I, 10 in H. The reciprocal percentages are 19 to A, 10 to 1, 1.6 to Bowden, .7 to G, .6 to I, .5 to H.

Fauna of Zone C.—Fossils were scarce in the glauconitic-like, bluish-green clays alternating with limestone which constituted this zone. Casts of *Pecten* and *Conus* were found but the only identifiable molluscan species was *Cassia sulcifera*, which ranges throughout our sections. Zone C is chiefly of interest as being the probable horizon of two sea urchins which were found loose. It is much to be regretted they were not *in situ*, since they suggest a Helvetian horizon.

Evidence of the Echinoderms.—Dr. Jackson has been so kind as to examine the Zone C sea urchins. They are the young and adult of the same species. He says of this *Clypeaster* in a letter dated April 27: "The *Clypeaster caudatus*, I should think from its comparison with other species was Miocene and I don't think there are any specimens in the other West Indian material that can be referred to the species. When I go down I will look closely and see if I can give you further clues to other West Indian forms."

In a later letter Dr. Jackson remarks: "I have been to Boston and went over the material carefully. The only specimens of *Clypeaster caudatus*, sp. nov. are those in Miss Maury's collection from Santo Domingo. The species makes perhaps closest approach to *Clypeaster lanceolatus* Cotteau which he described from Cuba and which I included (with photographs) from the Panama Canal Zone."

I may add regarding Echinoderms that Senor Rodolfo Cambiarso of Santo Domingo City most kindly presented me with a

splendid specimen from Gato on the southern side of the Island. Dr. Jackson identified this as *Clypeaster Dalli* (Twitchell). It was published as *Diplotheccanthus Dalli* Twitchell in W. B. Clark and M. W. Twitchell, 1915, Mesozoic and Cenozoic Echinodermata of the U. S., p. 218, Pl. 99, figs. 2a-b, Pl. 100, figs. 1a-b. Dr. Jackson writes: "*Diplotheccanthus* is one of Duncan's genera and H. L. Clark says it is not separable from *Clypeaster* in his opinion.

"*Diplotheccanthus Dalli* (Twitchell) was originally described from the Caloosahatchie Pliocene."

Fauna of Zone D.—We found the following molluscs in this zone :

List of Species

<i>Terebra inæqualis</i> Sby.	<i>Murex messorius</i> Sby.
<i>Conus proteus</i> Hwass.	<i>Murex cornurectus</i> Gpy.
<i>Conus Olssoni</i> , n. sp.	<i>Murex præpauillus</i> , n. sp.
<i>Conus recognitus</i> Gpy.	<i>Aspella scalarioides</i> Blainville.
<i>Conus marginatus</i> Sby.	<i>Coralliophila miocenica</i> Gpy.
<i>Surcula labiata</i> Gabb.	<i>Gutturium gracile gurabonicum</i> ,
<i>Drillia venusta</i> Sby.	n. var.
<i>Drillia losquemadica</i> , n. sp.	<i>Distortrix simillima</i> Sby.
<i>Drillia Donalbertonis</i> , n. sp.	<i>Bursa bufoniopsis</i> , n. sp.
<i>Drillia hispaniolæ</i> , n. sp.	<i>Cassis sulcifera</i> Sby.
<i>Clava plebeia</i> Sby.	<i>Sconsia lævigata</i> Sby.
<i>Clathurella Vendryesiana</i> Dall.	<i>Morum domingense</i> Sby.
<i>Trigonostoma gurabis</i> , n. sp.	<i>Cypræa spurcoides</i> Gabb.
<i>Olivella Sancti-Dominici</i> , n. sp.	<i>Cypræa dominicensis</i> ? Gabb.
<i>Marginella coniformis</i> Sby.	<i>Cypræa Gabbiana</i> Gpy.
<i>Lyria pulchella</i> Sby.	<i>Cerithium microlineatum</i> Gabb.
<i>Mitra quemadica</i> , n. sp.	<i>Cerithium Russellii</i> , n. sp.
<i>Strigatella</i> ? <i>perturbatrix</i> , n. sp.	<i>Cerithium uniseriale</i> Sby.
<i>Costellaria Bullennewtoni</i> , n. sp.	<i>Cerithium gurabense</i> , n. sp.
<i>Fusus Henekeni haitensis</i> Sby.	<i>Cerithium dominicense</i> Gabb.
<i>Latirus fusiformis</i> Gabb.	<i>Siliquaria gurabensis</i> , n. sp.
<i>Vasum dominicense gurabicum</i> ,	<i>Turritella tornata</i> Gpy.
n. var.	<i>Turritella submortoni</i> , n. sp.
<i>Phos elegans</i> Gpy.	<i>Polinices subclausa</i> Sby.
<i>Phos Guppyi</i> Gabb.	<i>Triforis Calypsonis</i> , n. sp.
<i>Alectrion gurabensis</i> , n. sp.	<i>Arca occidentalis</i> Philippi
<i>Alectrion losquemadica</i> , n. sp.	<i>Barbatia</i> cf. <i>Bonaczyi</i> Gabb.

- | | |
|---------------------------------|-----------------------|
| Strombina Bassi, n. sp. | Ostrea haitensis Sby. |
| Nitidella cibaoica, n. sp. | Ostrea virginica Gm. |
| Spondylus gumanomocon B. and P. | |

Affinities of the Zone D Fauna.—Of this list 28 per cent occur in Zone E, 24 in Bowden, 15 in Bluff 1, 14 in Bluff 3, 10 in H, 8 in F, 7 in I. The reciprocal percentages are : 10 to E, 2 to Bluff 1, 1 to F, 1 to Bowden, .8 to H, .7 to Bluff 3, .4 to I. The strong bond is with E. The genus *Cerithium* is so abundant that we called D the *Cerithium* zone in the field. Both D and E contain the striking species *Costellaria Bullennewtoni* which we found nowhere else.

Fauna of Zone E.—The following molluscs were collected :

List of Species

- | | |
|-----------------------------------|-------------------------------------|
| Terebra inæqualis Sby. | Distortrix simillima Sby. |
| Conus haytensis Sby. | Cassis sulcifera Sby. |
| Conus symmetricus Sby. | Sconsia lævigata Sby. |
| Conus Sewalli, n. sp. | Morum domingense Sby. |
| Conus consobrinus Sby. | Cypræa Henekeni Sby. |
| Conus tortuosostriatus Toul. | Strombus haitensis Sby. |
| Conus Karlschmidt, n. sp. | Strombus bifrons Sby. |
| Surcula labiata Gabb. | Strombus proximus Sby. |
| Turris albida Perry. | Cerithium microlineatum Gabb. |
| Drillia venusta Sby. | Petalconchus Laddfranklinæ, |
| Clava plebeia Sby. | n. sp. |
| Cancellaria (Narona) losque- | Turritella tornata Gpy. |
| madica, n. sp. | Turritella submorton, n. sp. |
| Marginella coniformis Sby. | Xenophora conchyliophora Born. |
| Lyræa pulchella Sby. | Natica Youngi, n. sp. |
| Mitra Henekeni Sby. | Natica (Stigmaulax) sulcata Born. |
| Mitra tortuosa Gabb. | Polinices subclausa Sby. |
| Costellaria Bullennewtoni, n. sp. | Sinum Nolani, n. sp. |
| Latirus infundibulum Gm. | Epitomium textuvestitum, n. sp. |
| Vasum haitense Sby. | Dentalium glaucoterrarum, n. sp. |
| Phos Moorei Gpy. | Scapharca losquemadica, n. sp. |
| Phos elegans Gpy. | Venericardia islahispaniolæ, n. sp. |
| Strombina Bassi, n. sp. | Cardium (Lævicardium) serratum |
| | Linné. |

Affinities of the Zone E Fauna.—Of this list 36 per cent occur in D, 43 in Bluff 1, 27 in Zone F. The reciprocal percentages are 12 to F, 12 to Bluff 1, 10 to D. That is, E is closely allied to the preceding and following faunas of D and F as one would expect, but shows also a strong bond with Bluff 1, not surprising when one considers how very strongly F and Bluff 1 are related.

Fauna of Zone F.—We obtained the following from this zone :

List of Species

Turris albida Perry.	Strombus bifrons Sby.
Clava plebeia Sby.	Sepulorbis papulosa Gpy.
Lyria pulchella Sby.	Xenophora conchyliophora Born.
Mitra Henekeni Sby.	Xenophora delecta Gpy.
Phos Moorei Gpy.	Turgurium imperforata Gabb.
Murex domingensis near yaquensis	Natica Youngi, n. sp.
Murex cornurectus Gpy.	Scapharca golfoyaquensis, n. sp.
Lotorium præfemorale, n. sp.	Glycimeris acuticostata Sby.
Cassis sulcifera Sby.	Pecten eugrammatus Dall.
Sconsia lævigata Sby.	Amusium papyraceum Gabb.
Morum domingense Sby	Spondylus bostrychites Gpy.
Malea camura Gpy.	Cardium (Lævicardium) serratum
Strombus haitensis Sby.	Linné.
	Antigona Blandiana Gpy.

Affinities of the Zone F Fauna.—Of the above, 70 per cent occur in Bluff 1, 46 in Zone E, 18 in Bluff 3, 20 in F, 8 in D. The reciprocal percentages are 19 to Bluff 1, 12 to Zone E, 2 to F, 1.6 to D, .7 to 3.

Description and Fauna of Zone G.—This horizon was found at the ford of the Cercado to Sabaneta road at the Gurabo river about two miles above Los Quemados. The exposures are low, rarely over ten feet. No line of contact could be found between G and F nor any sign of unconformity but even in the field the fauna of G appeared markedly different from the faunas of the preceding zones. The fossiliferous lenses occur in the upper beds

Sketch Map, Bulletin 29, facing page 10, Nos. 9 and 16. A view of the river, taken by Mr. Schmidt, showing Zone H is given in this Bulletin, Plate 3A.

Section at Cana

This exposure occurs just above the ford of the Mao to Guayubin road at Cana.

	Feet
Bluff composed of hard, blocky, blue clay weathering yellow.	
Cracks filled with gypsum. Fossils include <i>Serpulorbis papulosa</i> and <i>Placunanomia lithobleta</i> . Thickness about.....	50

Both the species mentioned are at Bowden. *Scapharca patricia* was found in the river debris but not *in situ*.

Section at Caimito.

This section is furnished by the successive bluffs extending along the river from two miles below to two miles above Caimito.

	Feet
Bluff two miles below Caimito. Argillaceous limestone with tubes of <i>Teredo incrassata</i> . Thickness.....	10-15
Heavy, sandy clays, Fucoids with Bryozoa, followed by gravels.	
In all about.....	30
Upper <i>Scapharca patricia</i> bed	1
Clay	4
Middle <i>Scapharca patricia</i> bed.....	1-2
Yellow sandy clays.....	20-25
Lower <i>Scapharca patricia</i> bed.....	1-2
Yellow unfossiliferous clays.....	15
<i>Chione</i> layer.....	1
Light yellow unfossiliferous clays.....	15
Lignitic layer.....	1
Lignite with <i>Scapharca patricia</i>	2
Gravels.....	3
Concealed.	
Zone H at the ford, Sabaneta to Cercado road, Caimito.	
Low exposures of blue and green clay, gravelly clays and pure gravels. Fossils in lenses. <i>Amauropsis</i> , <i>Neverita nereidis</i> , <i>Scapharca Willardaeuseni</i> , about.....	50
Bluff farther up the river, composed of uniform hard clays with lines of large concretions. (See Plate 3A). Unfossiliferous except for a few <i>Tellina</i> . Approximately.....	35
Gravels with compound corals at the top. Corals bored by <i>Petricola</i> , <i>Botula</i> , <i>Lithophaga</i> , <i>Coralliophaga</i> . About.....	15

Zone I. Above Caimito. Orchid gorge. Hard greenish clays with <i>Tellinas</i> . River narrows. Approximate thickness.....	50
Two miles above Caimito. Sandy clays with fossils in lenses. Irregular concretions. <i>Bullaria Sarahberlinere</i> found here. Thickness about.....	50
Sandy clays with lignitic streaks resembling those at Sabaneta. Approximately	100
Unexplored.	

Presence of Gypsum.—From the *Chlor* layer to the top of the Fucoid and Bryozoan beds gypsum is found both as thin plates filling nearly vertical cracks, and as clear, transparent selenite crystals. The shells of *Scapharca patricia* are also all encrusted with gypsum crystals.

The presence of gypsum indicates a period of aridity and excessive evaporation. It recalls the gypsiferous strata of the Grand Gulf beds.

Fauna of Zone II.—We found a rich fauna with many boring molluscs in the corals.

List of Species

<i>Acteocina canaliculata</i> Say.	<i>Arca occidentalis</i> Philippi.
<i>Acteocina</i> (<i>Cylichnella</i>)	<i>Arca umbonata</i> Lamarck.
<i>triticum-tritonis</i> , n. sp.	<i>Barbatia submarylandica</i> , n. sp.
<i>Retusa yaquensis</i> , n. sp.	<i>Scapharca golfoyaquensis</i> , n. sp.
<i>Bullaria paupercula</i> Sby.	<i>Scapharca caimitica</i> , n. sp.
<i>Terebra Berlineræ</i> , n. sp.	<i>Scapharca riocanensis</i> , n. sp.
<i>Conus haytensis</i> Sby.	<i>Scapharca Willardausteni</i> , n. sp.
<i>Conus proteus</i> Hwass.	<i>Pecten nodosus</i> Linné.
<i>Conus furvoides</i> Gabb.	<i>Botula hispaniolæ</i> , n. sp.
<i>Conus Kitteredgæi</i> , n. sp.	<i>Lithophaga antillarum</i> d'Orb.
<i>Conus recognitus</i> Gpy.	<i>Lithophaga nigra</i> d'Orb.
<i>Cythara elongata</i> Gabb.	<i>Mytilopsis domingensis</i> Recluz.
<i>Cancellaria Harrisii</i> n. sp.	<i>Coralliophaga coralliophaga</i> Gm.
<i>Oliva cylindrica</i> Sby.	<i>Chama caimitica</i> , n. sp.
<i>Oliva Cristobalcoloni</i> , n. sp.	<i>Chama congregatoides</i> , n. sp.
<i>Oliva brevispira</i> Gabb.	<i>Chama riocanica</i> , n. sp.
<i>Olivella muticoides</i> Gabb.	<i>Codakia orbicularis</i> Linné.
<i>Mitra Henekeni</i> Sby.	<i>Lucina chrysostoma</i> Philippi.
<i>Fusus Henekeni</i> Sby.	<i>Miltha riocanensis</i> , n. sp.
<i>Fusus Henekeni</i> Veatchi, n. var.	<i>Phacoides yaquensis</i> Gabb.

Phos fasciolatus Dall.	Phacoides actinus Dall.
Strombina Nanniebellæ, n. sp.	Cardium lingua-tigris, n. sp.
Murex cornurectus Gpy.	Cardium tintinnabularum, n. sp.
Cassis sulcifera Sby.	Pitaria circinata Born.
Phalium moniliferum Gpy.	Autigona tarquinia Dall.
Cypræa Henekeni Sby.	Petricola caimitica, n. sp.
Strombus bifrons Sby.	Petricola riocanensis, n. sp.
Natica (Stigmaulax) sulcata Born.	Tellina riocanensis, n. sp.
Polinices subclausa Sby.	Tellina cibaoica, n. sp.
Neverita nereidis, n. sp.	Scissula scitula Dall.
Amauropsis Guppyi Gabb.	Strigilla caimitica, n. sp.
Turbonilla turritissima Gpy.	Donax æqualis Gabb.
Turbo crenulatoides, n. sp.	Siliqua subæqualis Gabb.
Astrarium Karlschmidti, n. sp.	Corbula dominicensis Gabb.
Fissuridea Henekeni, n. sp.	Corbula caimitica, n. sp.

Affinities of the Zone II Fauna.—Of this list 32 per cent occur in Bluff 3, 32 in Zone I, 27 at Bowden, 14 in Zone G. The reciprocal percentages are 11.5 to I, 4 to Bluff 3, 2.9 to Zone G, 2 to Bluff 1, 1.8 to Zone F, 1 to Bowden.

Fauna of Zone I.—The following were obtained from this horizon :

List of Species

Volvula cylindrica Gabb.	Strombus proximus Sby.
Bullaria paupercula Sby.	Solarium granulatum Lamarck.
Bullaria Sarahberlineræ, n. sp.	Natica canrena Linné.
Bullaria granosa Sby.	Natica Youngi, n. sp.
Terebra spirifera Dall.	Natica sulcata Born.
Terebra cirrus Dall.	Polinices subclausa Sby.
Terebra Berlineræ, n. sp.	Neverita nereidis, n. sp.
Conus furvoides Gabb.	Amauropsis Guppyi Gabb.
Conus Kitteredgei, n. sp.	Niso grandis Gabb.
Conus recognitus Gpy.	Turbo dominicensis Laloï, n. var.
Turris albida virgo Lamarck.	Astrarium Karlschmidti, n. sp.
Drillia islalindæ, n. sp.	Leda peltella Dall.
Cythara caimitica, n. sp.	Arca yaquensis n. sp.
Glyphostyma golfoyaquensis, n. sp.	Scapharca inæquilateralis Gpy.
Cancellaria Harris, n. sp.	Scapharca cibaoica, n. sp.
Aphera islacolonis, n. sp.	Glycimeris jamaicensis Dall.
Oliva cylindrica Sby.	Pecten thetidis Sby.

Oliva Cristobalcoloni, n. sp.	Amusium papyraceum Gabb.
Oliva brevispira Gabb.	Pecten caimitica, n. sp.
Mitra Henekeni Sby.	Venericardia scabricostata Gpy.
Fusus Henekeni haitensis Sby.	Divaricella prevaricata Gpy.
Melongena consors Sby.	Diplodonta puncturella Dall.
Phos fasciolatus Dall.	Cardium haitense Sby.
Strombina Nanniebellæ, n. sp.	Pitaria circinata Born.
Murex cornurectus Gpy.	Pitaria planivieta Gpy.
Cassis sulcifera Sby.	Chione Woodwardi Gpy.
Phalium moniliferum Gpy.	Chione (Lirophora) Hendersoni Dall.
Pyrula Pilsbryi Smith	Tellina riocanensis n. sp.
Cypræa Henekeni Sby.	Macoma cf. constricta Bruguière.
Cypræa spurca Linné.	Semele Claytoni, n. sp.
Trivia globosa Gray.	Solen obliquus Spengler.
	Corbula vieta Gpy.

Affinities of the Zone I Fauna.—The reciprocal percentages are as follows: 14 to G, 11.5 to H, 6 to Bluff 3, .5 to Zone A, .4 to D. The strongest bond is with G, next in order come H and Bluff 3. But there is next to nothing in common with A and D.

GEOLOGY OF THE RIO YAGUAJAL

A characteristic view of the Rio Yaguajal near Sabaneta is shown on Plate 1A of this bulletin. A general description of Sabaneta and its surroundings is given in the narration of our expedition, Bulletin 29, page 4. The location is shown on the Sketch Map facing page 10 of that bulletin.

The composition of the beds is well shown by several bluffs along the Yaguajal. These exhibit considerable variation. At one place the basal layer will be a heavy gravel, at another a pure, hard blue clay. When traced even in a short distance the pure clay may merge horizontally into gravel. In nearly all the bluffs the blue clays alternate with gravel and locally lignite seams are present, as in the Cana section. Elsewhere the clay may contain large, rounded concretions also as along the Cana. In the upper parts of the bluffs the clays have weathered to a yellowish hue. No fossils were found in place.

Section of Sabaneta Bluff

	Feet
4. Superficial gravels.	
3. Light yellow, soft material with thin beds of harder rock projecting as small shelves.....	25
2. Gravels composed largely of small, angular quartz fragments mingled also with those of crystalline rocks. On making a fresh cut the gravels were found to alternate with thin layers of pure clay and lignite seams. At the base of the gravels is a heavy blue clay mixed with much fine quartz.	50
1. Greenish-blue clay, quite hard, slopes convex. No fossils. Exposed.....	10

The only fossils found were two valves of *Scapharca patricia* and one of *S. auriculata* but they were lying loose on top of 3. Their origin is unknown.

Tentative correlation of the Sabaneta beds.—Judging from the prevailing northern dip, calculated as noted at Los Quemados, the general line of strike is N. E. and S. W. and the Sabaneta section would lie approximately along the line of strike of the Caimito and Los Quemados sections to the northeast. Thus probably the alternating clays, gravels and lignitic seams of Sabaneta are to be correlated with the gravels, clays and lignitic sands of Zones H and I. Possibly the upper bed at Sabaneta represents the *Arca patricia* horizon of the Cana but this is very doubtful.

Gabb's Sabaneta Section

In 1873 Gabb published* a section obtained near Sabaneta, where the road crosses the Yaguajal, which he correlated with exposures elsewhere and used in his ideal section of the Santo Domingo "Miocene" formation, page 95 *loc. cit.* His conclusions may be indicated briefly as follows :

Correlation	Sabaneta	Feet
Gravels of the Mao.	Gravels.	20
Yellow	Yellow sandy clay shales.	12

*Trans. Amer. Philosophical Soc., vol. 15, p. 154.

shales	Lignite.	2½ in.
of	Yellow sandy clay shales.	7
Guayubin.	Lignite.	3½ in.
Nivaje	Blue shales.	Depth
shale.		unknown.

Comparisons of Gabb's Conclusions with Ours

The Gravels.—Gabb recognizes but one set of gravels which forms the top of his Sabaneta section and is correlated with the Mao gravels.

Our section shows that in addition to these gravels there are older gravels intermingled with the blue clays. In short there are superficial, probably Quaternary, gravels and Tertiary gravels. The surface gravels are described in the Sketch of our Expedition (pages 3-4, Bulletin 29) as reddish and extending all the way from Las Matas to Sabaneta, and they form the gravelly knolls on top of the savannahs around Sabaneta. These gravels also occur in the river terraces. The Tertiary gravels noted in our Sabaneta section were also found in the Cana section Zones H and I and lie near the base of the formations studied by us.

The Yellow Shales of Guayubin.—The differentiation into yellow shales is not a good one because the blue shales weather yellow and their surface exposures are always yellow. To Gabb all yellow shales are Guayubin shales but quite probably the Guayubin shales are simply weathered equivalents of the blue shale. However as Guayubin was rebel we could not study the formations there satisfactorily.

As noted (Bulletin 29, page 7) in the region traversed by our party the so-called blue and yellow shales were really hard clays not consolidated nor laminated. Hence we have throughout this memoir called them clays.

The Blue Shales.—These are also called the blue shales of Santiago and the Nivaje shale. The latter name was given because of their typical development on the Nivaje arroyo which enters the Rio Yaqui near Santiago. See Sketch Map facing page 10, Bulletin 29. Most unfortunately, the Revolution prevented

our visiting the Nivaje and Upper Yaqui but we hope to do so later. Our collections and sections from the regions farther west however sufficiently indicate that all blue clays are not alike in age. They are not a unit, but one set, represented by Zones A-F and Bluff 1, occurs above the Tertiary gravel, and another set, represented by lower H and G and Bluffs 2 and 3, occurs with and below the Tertiary gravels. It remains to be proven in the field whether the true "Nivaje shale" goes with the upper or the lower set.

Tertiary and Quaternary Oscillations of Level

The alternation of Tertiary gravel with clays as shown in our Sabaneta and Cana sections indicates alternate elevations and depressions of the shore line.

Terraces furnish another indication of changes of level. The high level terraces seen from the bluff at Hato Viejo on the Mao, plate 2B, have been described on page 8, Bulletin 29.

A striking indication of rather recent uplift is the rejuvenation of the Rio Cana described on page 9 of that bulletin.

Gabb* gives an interesting account of the raised sea caves in the Post Pliocene coastal limestone, in one of which he made his camp, and he remarks that they prove the recent, "and yet continuing," uplifting of the land. I saw a great many sea caves in process of formation on passing around the eastern and south-eastern part of Santo Domingo and was informed that on the small, uninhabited Island of Saona there are two level sea caves.

These indications of uplift accord with those recorded by the raised coral reefs of Jamaica noted by Hill, and those of the Brazilian coast studied by Branner. Similar changes have also been noted in Porto Rico.

GEOLOGY OF EL MORRO DE MONTE CRISTI

The location of the Morro is shown on the Sketch Map, fac-

*Trans. Amer. Phil. Soc., vol. 15, p. 146, 1873.

ing page 10, Bulletin 29. It is separated from the main land by a belt of salt marsh traversed by tidal rivulets. The highest point of the Morro rises 825 feet above the sea. Columbus is said to have named it Monte Cristi from the thorny bushes crowning its summit. It was later called La Grange by the French from a fanciful resemblance from certain viewpoints to a huge barn.

Heneken's Conclusions.—Colonel Heneken* first studied this interesting hill in 1853. He notes that on the northern face the base is of red sandstone, dipping N. W. by N. 7° , overlain conformably by blue fossiliferous shale and this by tufaceous limestone. On the western face he observed the intercalation of blue and yellow shales and noted that the latter appear a larger development of the Cercado shales. He correlated the limestone cap with the limestone capping the Samba Hills. In a section from the Morro to Guaraguano Heneken gives the following :

Tertiary	{	1. Tufaceous limestone.†
		2. Shingle bed.
		3. Argillo-calcareous shales.
		4. Blue and green fossiliferous shales.
		5. Red sandstone, unfossiliferous.
		6. Micaceous schist.
		7. Limestone.
		8. Greenstone.

Section of the Morro

During our stay at Monte Cristi the north side of the Morro was unsafe because of lurking bandits and rebels. Mr. Schmidt, however, obtained a photograph of the northern end shown on Plate 2A. Our collections were made from the calcareous yellow clays and the limestone of the southern side where the blue clays are not present. The relation of the north and south sides could

*Quart. Jour. Geol. Soc. London, vol. 9, pp. 125, 126, 1853.

†The name "Tufaceous" was later abandoned as analysis showed it to be a misnomer.

not be worked out at the time for the reason mentioned. The following is a generalized section of the southwest face.

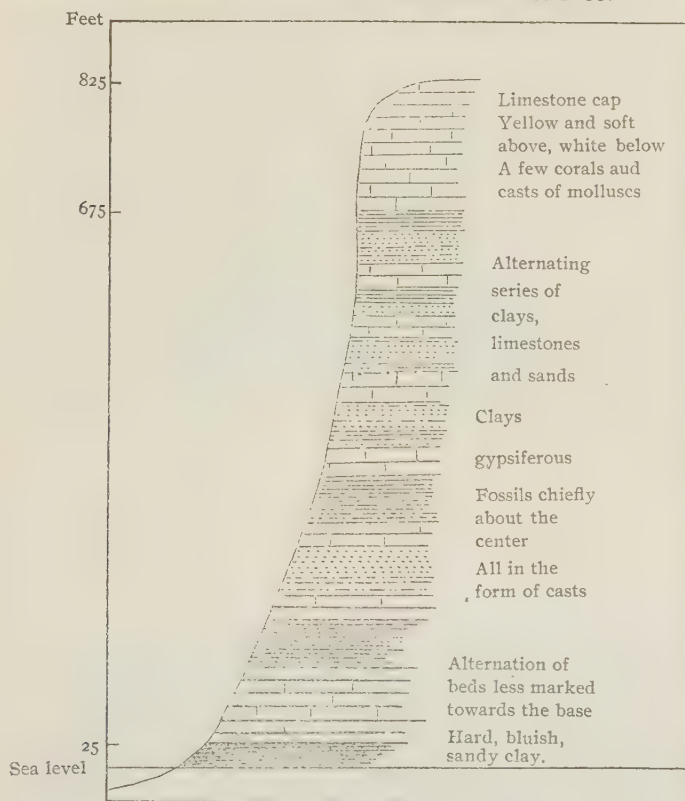


Fig. 1 Section of El Morro

The Basal Sandy Clay.—This probably represents Heneken's "red sandstone." Gabb* emphatically denied the existence of Heneken's red sandstone and restricted it to Heneken's imagination. The only sandstone observed by our party was that outcropping in the town of Monte Cristi and upon which the fort is built. The dip of this sandstone is very high. It is really gray but often reddish or yellowish on the surface from oxidation. Ap-

*Trans. Amer. Phil. Soc., vol. 15, p. 95, 1873.

parently Heneken erroneously inferred that the Monte Cristi sandstone was continuous with the Santiago sandstone (which we have not seen) and that it underlay the entire Yaqui Valley.

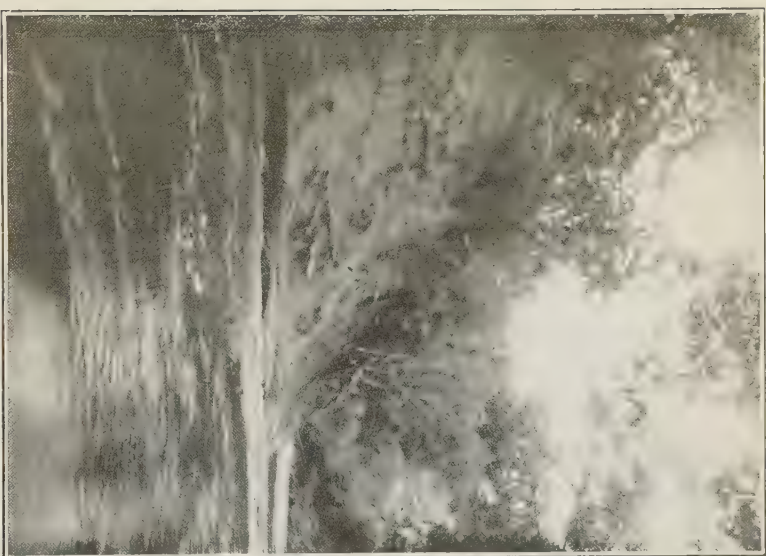
Calcareous Clays.—These form about three-quarters of the total thickness of the section and contain casts of a number of molluscs among which the following only could be determined: *Sconsia laevigata* Sowerby, *Strombus bifrons* Sowerby, *Olivella muticoides* Gabb, *Natica* cf. *Youngi* Maury, *Chione Woodwardi* Guppy. Of these *Sconsia laevigata* is found in Zones A, B, E, F of Rio Gurabo, Bluff 1 at Cercado and at Bowden; *Strombus bifrons* in Zones A, E, F, Bluffs 1 and 3 and Bowden; *Olivella muticoides* in Zones G and H of the Gurabo and Cana rivers; *Chione Woodwardi* in Bluffs 2 and 3 and Zones H and I. Hence two of the formations of the Yaqui valley seem to be represented on the Morro.

The clays are gypsiferous, thin plates filling the cracks as in the *Scapharea patricia* beds of the Cana river.

Limestone Cap.—This is about two hundred feet thick, white below, yellowish from weathering above. Casts of *Pecten*, *Glycimeris* and *Conus* were found but not specifically identifiable. Corals were also present. Gabb followed Heneken in considering this limestone to be a continuation of that capping the Samba Hills, the intervening part having been removed by denudation. The probability of this is greatly enhanced by our collecting specimens of a coral, kindly identified for me by Dr. Vaughan as *Syzygophyllia dentata* (Duncan), from both the Morro limestone and that of the Samba Hills. This species also occurs in Zones C and D, Rio Gurabo.

GEOLOGICAL NOTES ON SCATTERED LOCALITIES

Section on the Samba Hills at about 540 feet altitude.—On the old road leading to the mines described in the route of our Expedition, Bulletin 29, pages 5 and 6, between Las Caobas and Rompino, the following section was obtained. The aneroid had not been reset for some time and the readings are approximate



A. Zone H, Rio Cuna at Cuinito



B. Zones A and B, Rio Curubo at Los Quemados

only. At 870 feet an unfossiliferous limestone bed was exposed, at 660 feet a bed of sandstone, at 600 feet a second sandstone bed outcropped, at 540 grayish and yellowish fossiliferous clays were found. The general surface of the Las Caobas plain is 480 feet. In the fossiliferous yellow clays in an arroyo were the following molluscs:—

List of Species

Calliostoma Grabaui, n. sp.	Pecten eugrammatus Dall.
Arca lomasdesamba, n. sp.	Pecten Thetidis Sby.
Barbatia cf. Bonaczyi Gabb.	Pecten vaginulus Dall.
Scapharca Henekeni, n. sp.	Amusium papyraceum Gabb.
Glycimeris acuticostata Sby.	Myrtæa lomasdesamba, n. sp.
Ostrea virginica Gm.	Cardium sambaicum, n. sp.
	Cardium serratum Linné.

Rio Amina.—Several bluffs composed of hard, light blue clays were examined on the Rio Amina between Hato Viejo and Potrero. See Sketch Map of Route (14) and (15). The bluffs at Hato Viejo being farther down the river and hence higher in the section, were found to be nearly barren, containing only a few fossils too poorly preserved to collect. Further up the river the bluffs become more fossiliferous but the fauna was still relatively scanty.

The dip along this portion of the river is very variable, changing from northerly to horizontal and southerly, thus proving the presence of an anticlinal fold. In the distance traversed the lower beds were not encountered.

Miss Rathbun kindly has identified the cheke which we collected on the trail to Potrero as those of *Petrochirus*, a genus with two living species, one West Indian, one on the west coast of America. Toula says he found *Petrochirus* in the Gatun beds.

List of Species

Acteocina ovum-lacerti Gpy.	Phos Gabbii Dall.
Terebra Gabbi Dall.	Phos elegans Gpy.
Terebra amitra Dall.	Phos fasciolatus Dall.
Terebra haitensis Dall.	Strombinella acuformis Dall.
Terebra cirrus Dall.	Bursa Amphitrites, n. sp.

Terebra oligomitra Dall.
 Turris albida Perry.
 Drillia venusta Sby.
 Cancellaria Rowelli Dall.
 Marginella amina Dall.
 Marginella domingoensis Dall.
 Lyria pulchella Sby.

Limopsis ovalis Gabb.
 Limopsis hatoviejonis, n. sp.
 Scapharca tolepis Dall.
 Glycimeris acuticostata Sby.
 Pecten eugrammatus Dall.
 Pecten hatoviejonis n. sp.
 Cardium aminense Dall.

Probably this horizon goes with Bluff 1 on Rio Mao and with A to F on the Gurabo. Our work on the Rio Amina was really just begun and it calls for further exploration which floods and rebels made impossible.

Guayubin to Mao road.—From an outcrop on this road at the ford of Rio Cana the following were collected :

List of Species

Conus catenatus Sby.	Scapharca Margaretæ, n. sp.
Murex domingensis Sby.	Scapharca guayubinica, n. sp.
Murex cornurectus Gpy.	Scapharca inæquilateralis Gpy.
Bursa crassa Dillwyn.	Scapharca patricia Sby.
Strombus pugiloides Gpy.	Ostrea megodon Hanley.
Serpulorbis granifera Say	Ostrea virginica Gm.
Serpulorbis papulosa Gpy.	Amusium papyraceum Gabb.
Polinices Stanislas-Meunieri, n. sp.	Placunanomia lithobleta Dall.
Barbatia (Calloarca)	Chama involuta Gpy.
submarylandica, n. sp.	Antigona Blandiana Gpy.

This horizon is allied with the upper series and appears quite high from the presence of *Arca patricia*. This we should expect from the outcrop being on the Lower Cana. Our deeper beds were found on the middle and upper portions of the river.

Bulla River.—Unidentified material was kindly loaned us by the American Museum from a bluff on the Bulla River, a small arroyo entering the River Mao. The location is indicated roughly on our Sketch Map, facing page 10, Bulletin 29. The precise location is not known.

List of Species

Volvula cylindrica Gabb.	Nucula tenuisculpta Gabb.
Conus Kitteredgeri, n. sp. var.	Scapharca Arthurpennelli, n. sp.

<i>Olivella</i> cf. <i>indivisa</i> Gpy.	<i>Scapharca</i> <i>riocanensis</i> ?, n. sp. (young)
<i>Marginella</i> <i>cercadensis</i> , n. sp.	<i>Phacoides</i> <i>yaquensis</i> Gabb.
<i>Strombina</i> cf. <i>pseudohaitensis</i> , n. sp.	<i>Phacoides</i> <i>cercadica</i> , n. sp.
<i>Natica</i> <i>sulcata</i> Born.	<i>Pitaria</i> <i>circinata</i> Born.
<i>Polinices</i> <i>subclausa</i> Sby.	<i>Pitaria</i> cf. <i>acuticostata</i> Gabb.
<i>Melanella</i> cf. <i>cercadica</i> , n. sp.	<i>Tellina</i> <i>scitula</i> Dall.
<i>Cadulus</i> <i>phenax</i> P. and S.	<i>Siliqua</i> <i>subæqualis</i> Gabb.
	<i>Corbula</i> <i>cercadica</i> , n. sp.

Of the 19 species in this list 15 are present in Bluff 3. The reciprocal percentage is 7. Undoubtedly this horizon goes with Bluff 3 at Cercado on the Mao.

DISCUSSION OF THE STRATIGRAPHY

Moore raised the question whether the collections made by Heneken in the Yaqui Valley might not represent more than one formation, and in late years Dall has suggested the same query. Heneken and Gabb, however, both thought that the fossils were from one formation. Gabb* states very emphatically that the whole valley is made up entirely and only of late Miocene strata and that no vertical differentiation of the horizons is possible.

To determine whether this was the case, or whether more than one formation was present, and to find the stratigraphic succession has been our main object.

While collecting from the bluffs of the Gurabo river on our 1916 Expedition, Mr. Olsson and Mr. Schmidt were struck by the change of fauna in Zone G from that of Zones A-F. A similar change in the faunas was found between Bluffs 2 and 3 and Bluff 1 on the Rio Mao. They were convinced that two formations were represented.

Subsequent critical study of all the various types of life we collected from the bluffs of the Gurabo, Mao and Cana Rivers has shown that their conclusion was justified.

The Geographical Sequence.—As the prevailing dip is a gentle one to the north, on going southward in ascending the southern tributaries of the Yaqui, as the Mao, Gurabo and Cana, one

*Trans. Amer. Phil. Soc., vol. 15, p. 101 and p. 158, 1873.

would expect to meet with successively older outcrops, providing this sequence had not been altered by folding or faulting. That this may take place is shown by the low anticline found between Hato Viejo and Potrero on Rio Amina. So while the geographical sequence is suggestive, we have placed little reliance upon it in the determination of the stratigraphy. But as a matter of fact it has practically coincided with the faunal evidence.

Evidence of the Mollusca.—In view of the large numbers of species from the various localities and the rarity of what might be taken as index fossils, the method of reciprocal percentages has been used, as already explained, to determine relationships. The results were very significant and may be briefly summarized.

Resumé of Reciprocal Percentages

Rio Mao at Cercado

Bluff 1	Bluff 2	Bluff 3
19.6 to F.		
14.—A.		
10—B.	1 to 1.	1 to 1.
* * *	* * *	.92—F.
3—3.	15—3.	* * *
2—G		15—2.
1.5—2.		7—Bulla R.
		6—I.
		4—H.
		3—G.

Rio Gurabo at Los Quemados.

Zone A	Zone B	Zone D
19 to B.	19 to A.	10 to E.
14—I.	10---I.	2—I.
* * *	* * *	* * *
1—3.	.7—G.	.8—H.
.7—G		.7---3.
.5—I.		.4---I.
.4--H.		

Zone E	Zone F	Zone G
12 to 1.	19 to 1.	1.9—F.
12---F	12---E.	.7---A.
10---D.		.2---B.
* * *	* * *	* * *
	2 to G.	14---I.
	.7 to 3.	3---H

Bulla River

	Zone H
	2 to 1.
	1.8---F.
* * *	* * *
7 to 3.	11.5---I.
	4---3.
	3---G.

Rio Cana

Zone I
.5---A.
.4---D.
* * *
14 to G.
11.5---H.
6---3.

The faunal changes, represented by stars, are indicated by a marked weakening of faunal bonds as evinced by the drop in percentages. Zones G at Los Quemados, H and I at Caimito and Bluffs 2 and 3 at Cercado form the lower formation and Zones A-F at Los Quemados and Bluff 1 Cercado, the upper. Strong bonds ally 1 and F, 1 and A and B, D and E, G and I, H and I, 2 and 3, 3 and I, 3 and Bulla River. But F and G and 1 and 2 are sharply set apart.

Evidence of the Corals.—As stated in Bulletin 29, we are much indebted to Dr. Vaughan for his kindness in writing a report on our corals and in obtaining for us from his colleagues summaries of the evidence furnished by our Foraminifera, Bryozoa, Echinoderms and Crustacea. The conclusions of Dr. Vaughan and his colleagues have been of great assistance and support.

Dr. Vaughan, on examining our corals, discovered a faunal break in this group in Zone H, Rio Cana at Caimito. This preceded the break in the molluscs, for those in H above the coral bed are still closely allied to the fauna of I. One of our problems that remains to be cleared up is the exploration of the interval between H and the *Arca patricia* beds. By inference with

the conditions on the Gurabo and Mao the change in the moluscan fauna on the Cana would come right above H in the unexplored region. That the change in the corals preceded the moluscan change at first seems contradictory, but as Professor Harris suggests, corals are extremely sensitive and would respond to the change of conditions from its very inception.

The few corals we obtained from the Gurabo and Mao river bluffs do not show the break between F and G and G and 1 and 2 and 3. Apparently several of the species lived as did a number of the molluscs but there were only three or four corals in F and G together and their evidence is outweighed by the hundreds of species of molluscs and the Bryozoa and Foramanifera, all of which agree in making a unit of Bluffs 2, 3, Zones G, H and I. This unit is set off from the overlying Zones A-F and Bluff 1 unit.

Dr. Vaughan considers that H is probably Chipolan; D and F, Alum Bluff above the Chipolan; E and D, uppermost Alum Bluff, *i. e.* uppermost Burdigalian; and A-C, perhaps Helvetian Miocene. According to Dr. Vaughan the Chipola and Alum Bluff horizons are Oligocene.

Formations of the Yaqui Valley.—The Tertiary clays and limestones of the Yaqui Valley seem to the writer to represent three well defined formations separated by marked changes in the molluscan faunas. These formations may be designated as follows:

- | | |
|-----------------------------------|-------------------|
| 3. The <i>Sconsia lævigata</i> | } Form-
ation. |
| 2. The <i>Apheræ islacolonis</i> | |
| 1. The <i>Orthaulax inornatus</i> | |

In addition to these the presence of an older formation carrying Gabb's "*Orbitoides*" (perhaps *Lepidocyclina*) and constituting the Monte Cristi Range is suggested, but awaits investigation in the field. Examination should be made of this range at various places, as on the trail near Alta Mira from Puerto Plato to Santiago to determine whether *Lepidocyclina* is present and the

relative age of the strata.

1. No one knows where Gabb found his *Orthaulax inornatus* because none of his Dominican fossils were labeled more precisely than, "Miocene, Santo Domingo." We presume, however, that it was collected from the basal blue clays in the Eastern part of the Yaqui Valley where the Revolution prevented our securing sections and collections. For in the Western part of the valley we have gone almost to the contact of the Tertiary with the older series (See crystalline outcrop near Sabaneta, Plate 2B, Bulletin 29) and although a special search was made for *Orthaulax* we did not find it. No doubt the *Orthaulax* zone represents an older horizon than from which we collected.

2. To designate the formation comprising our Bluffs 2, 3, Zones G, H and I, I have chosen *Cancellaria* (*Aphera*) *islacolonis* (See Bulletin 29, p. 65, pl. 10, fig. 12a, b) of which the descendant, *A. tessellata*, is now living in the Pacific. *A. islacolonis* after occurring in the beds mentioned disappears abruptly. I have never found it above the faunal break. Hence it seems a good index fossil of the lower formation.

3. Very characteristic of the upper formation and extending into what may possibly be the Helvetian strata of A-C, is *Sconsia laevigata*, of which the nearest living ally is the deep water *S. barbudensis*. *S. laevigata* is present in A, B, D, E, F, Bluff 1 and the Morro. I have never found it below F or Bluff 1. It seems the best guide to the upper formation.

The possibility that the upper part of the *Sconsia* formation grades into the Helvetian Miocene, as suggested by Dr. Vaughan and Dr. Jackson, is very interesting, but judging from the evidence given by the molluscs, is exceedingly doubtful since the bonds between A and B and Bluff 1 and F are very close.

Suggested Analogies with Porto Rico.—Dr. Berkey in his Reconnaissance of Porto Rico* found a great unconformity separating an Older Series of Cretaceous interbedded limestones, tuffs and shales from a Younger Series of Tertiary shales, limestones and sands, which range from the Lares shales to the Pleistocene dune

*Ann. New York Acad. Sci., vol. 26, p. 61, 1915.

sands. The latter are followed by the comparatively recent flood plain deposits. The fossils have not yet been identified so exact comparisons are not possible yet certain analogies are suggested. Thus near Bucaro, 27 miles west of Santo Domingo City at the copper mines, beds of tuffs occur capped by limestone. These seemingly correspond to certain of the Porto Rican tuffs. The Lares shales may go with the *Orthaulax* zone of the Yaqui Valley or perhaps with the probably older Monte Cristi range. The limestones and marls above the Lares shales perhaps correspond to our *Aphera* and *Sconsia* formations. The terraces recall the Dominican terraces seen from Hato Viejo, while the flood plain deposits are probably synchronous with the flood plain of the Rio Yaqui.

Correlation of the Yaqui Valley Horizons with those of France and Florida.—The resemblance of the fossil shells from the blue clays of the Yaqui Valley to those of Bordeaux and Dax was noted from the very first by Moore, Sowerby and Guppy. In modern French nomenclature the fossiliferous marls of the Bordelais are placed in the Lower Neogene comprising a lower, Aquitanian series typical at Léognan and Saucats and an upper, Burdigalian series typical at St. Paul and Dax in the Adour Valley. The Aquitanian was at one time regarded as Oligocene but modern French stratigraphers place it in the Lower Miocene.

The Dominican *Orthaulax* Formation is older than those of Bordeaux and represents approximately the Rupelian Oligocene of Europe and the Tampa siliceous beds and White Beach limestone of Florida. It comes in just above the Vicksburg limestone.

The *Aphera* Formation represents the Chipola marls of Florida and the Upper Aquitanian of the Bordelais. In modern French nomenclature this is Lower Miocene.

The *Sconsia* Formation would represent the overlying Burdigalian and the cross-bedded sands above the Chipola marls of Alum Bluff, Florida, also the Oak Grove sands of Florida. Recent French authors classify the Burdigalian as Middle Miocene.

We then called the crossbedded sands and Oak Grove sands Transitional, for which Burdigalian should now be substituted.

Whether, as suggested by the loose *Clypeaster caudatus*, the Helvetian subdivision of the Vindobonian Miocene comes in at C remains to be proved or disproved. The Helvetian is basal Upper Miocene of recent European usage but basal Miocene of certain American authors. If present it would show that a warm water fauna was living in the Dominican waters before, or possibly simultaneously with, the cold water Chesapeake (Tortonian?) fauna extending along the American coast.

GENERAL CORRELATION TABLE.

A summary of the main conclusions reached may be most clearly expressed by the following table.

CORRELATION OF SECTIONS IN THE YAQUI

Formations.	The Morro at Monte Cristi.	Sabaneta Rio Yaguajal.	Cana, Caimito Rio Cana.	Los Quemados Rio Gurabo.	Cercado de Mao.	Bulla River.	Jamaica.	Panama.
* * * *	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *
<i>Sconsia laevigata.</i>	Limestone cap Upper argillaceous limestones with <i>Sconsia</i> .	Upper bed (3) of section.	† <i>Serpulorbis</i> bed at Cana. † <i>Teredo</i> limestone at Caimito. † <i>Arca patricia</i> beds. Change to aridity. Unexplored.	A B C† D E F	Bluff No. I.		Fossiliferous, calcareous gravels of Bowden, seemingly	Gatun beds with <i>Sconsia</i> .
* * * *	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *
<i>Aphera islaconis</i>	Lower argillaceous limestones.	Gravels with basal blue clays, lignitic, (2) of section. Hard green clays and lig- nite (1) of section.	H Clays and gravels. Coral change. Upper I Clays, sands gravels and lignite Lower I.		Bluff No. 2. Bluff No. 3.	Bulla River Bluff.	a mixed fauna representing these two formations.	
* * * *	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *	* * * *
<i>Orthaulax inornatus.</i>	Santo Domingo is the type locality of Gabb's <i>Orthaulax</i> but its exact location is not known, probably the basal beds of the Eastern Yaqui Valley. This formation is older than Bowden where <i>Orthaulax</i> has never been found.							

Possible lower formation represented by the Monte Cristi Range with Gabb's "*Orbitoides*."

†Indicates position doubtful. ‡Possible commencement of Helvetian but very questionable.

VALLEY

Florida.	Europe.	Stage.
* * * *	* * * *	* * * *
Alum Bluff crossbedded sands and sands of Oak Grove.	? Helvetian * * * *	Up. Miocene. * * * *
* * * *	* * * *	* * * *
Marls of the Chipola River.	Burdi- galian. Upper Aquitanian.	Middle Miocene. Lower Miocene.
* * * *	* * * *	* * * *
Tampa silex beds with <i>Orthis</i> <i>inornatus</i> .	Rupelian.	Oligocene.
* * * *	* * * *	* * * *

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